SIS Football Analytics Challenge

July 2020

Sam Struthers
Adrian Cadena

Index

Challenge

1. Which is the most valuable defensive line position?
2. What is the nature of the distribution of talent between the defensive line positions?
3. In which in-game or roster construction scenarios would the answer to Question 1 change?

Not all situations are created equal

- Pass and run defense situations will be analyzed separately
- We will be making clear distinctions between 3-DL-front defenses (Front 3) and 4-DL-front defenses (Front 4)
- These premises will be taken into consideration when answering competition questions

What is Talent?

For practicality, we will define talent as “individual ability”. We measure ability by **quantifying** the **positive or negative impact** that a player has on a given play, game, or season.

What is positional value?

Positions where players’ ability (individual impact) is spread-out the most (higher variance), will be considered more valuable.

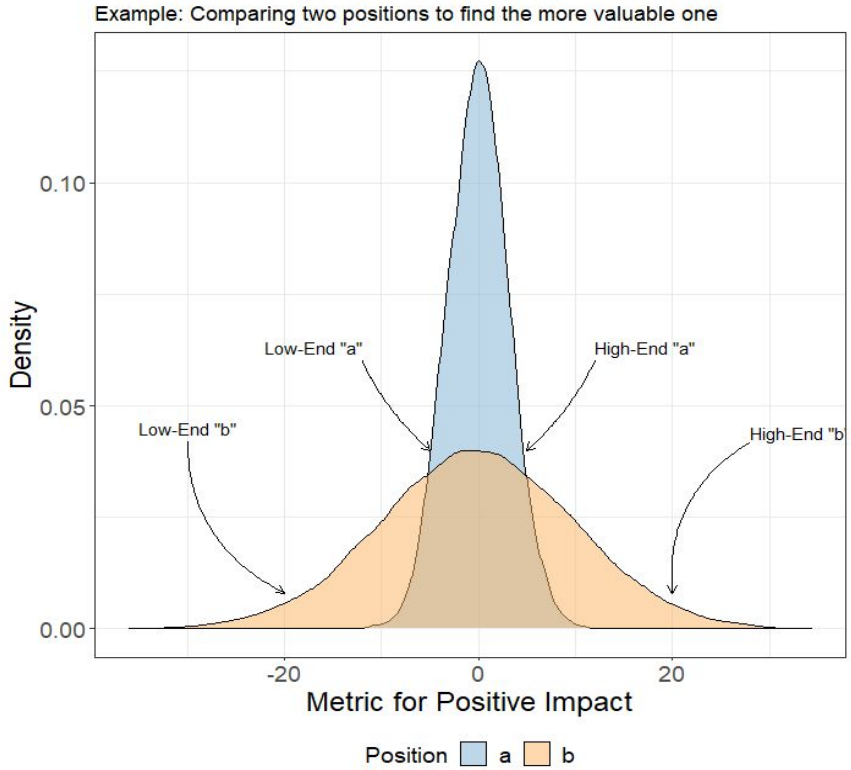
What is positional value? cont.

In our graphic example, we see two positions with different variances in player ability.

Position “a” (low variance): the difference in impact from a high-end to a low-end player is not very pronounced.

Position “b” (high variance): there is a large difference in impact from a high-end to a low-end player.

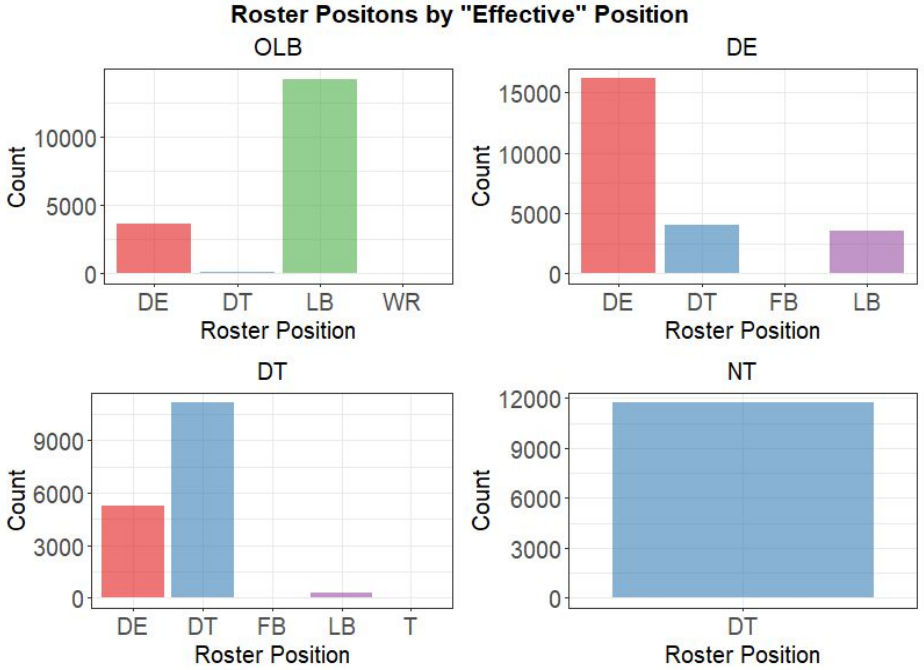
Position “b” is more valuable than “a”.



Positions

- Defined four different “effective” positions and two “broad” positions
- “Effective” Positions were defined using On-Field position and Technique Name Roster Position was used to differentiate DBs from LBs in some instances
- Created a NT Position variable to differentiate players who line up primarily across from the Center/inside Guards
- Effective Positions: NT, DT, DE, and OLB
- Broad Positions: EDGE (DE+OLB) and iDL(NT+DT)
- iDLs will sometimes be referred as interior defenders and EDGE as EDGE defenders

“Effective Positions” vs “Roster Positions” from SIS data



Data source: Sports Info Solutions

- OLB: mostly LBs and DEs
- DE: mostly DEs plus a combination of DT and LB
- A couple of observations with Offensive Players (insignificant)

“Broad Positions” vs “Roster Positions” from SIS data

- **EDGE:** label given to all OLBs and DEs
- **iDL:** label given to all NTs and DTs

For sample size purposes, most times we will be comparing iDL to OLB and DE.

Sometimes EDGE to iDL

Other Assumptions

- Filtered out spikes and QB kneels.
- QB Scrambles were classified as pass plays.
- The passing game is considered to be the strongest weapon of an offense: we assume that making an impact on the oppositions passing game is more valuable than impacting their running game
    - (2019 - Weeks 9 to 17) mean EPA/pass: -0.015*
    - (2019 - Weeks 9 to 17) mean EPA/run: -0.038
- Treating OLB (OnFieldPosition = LB & TechniqueName = Outside) as a DL position when analysing front 3 formations. Front 4 will not take OLB into consideration due small sample size. This will be explained more in detail during the presentation
- Other assumptions will be stated throughout the presentation

Engineered Variables

- **run_num :** assigning a number to each run gap from 0-8 based on RunDirection. (Example: 0 = Right Off Tackle D Gap, 8=Left Off Tackle D Gap)
- **tech_num:** assigning a number to each technique from 0-8.5 based on SideOfBall and TechniqueNumber. (Right Side 9 Tech is an 8.5, Left Side 9 Tech is a 0). In order to create a distance_from_gap variable
- **distance_from_gap:** distance from the designed run gap in terms of “gaps”. For example, a DT playing 3-technique on the right side of the ball (Defensive Perspective) would be one gap away from a run designed for the Left A Gap
- **mean_dist:** mean distance_from_gap of all players on the play
- **min_dist:** distance_from_gap of the closest defender to the designed run on the play

Engineered Variables cont.

- **min_dist_2:** distance_from_gap of the second closest defender to the designed run on the play
- **distance:** to bin distance_from_gap variable into 4 classes: close, mid, mid-far, or far from the designed run gap
- **RunAtDefender**: if defender is <=1 gap away from run
- **num_DT:** number of DTs on the play
- **num_DE:** number of DEs on the play
- **num_NT:** number of NTs on the play
- **num_OLB:** number of OLBs on the play
- **Yardline_100:** Yardline at the moment of the play: Smaller as OffensiveTeam gets closer to DefensiveTeam end zone

Engineered Variables cont.

- **blitz:** dummy variable for blitz. If more than 4 players are rushing, blitz is 1
- **de_pressuring:** number of DEs pressuring the QB on the play
- **idl_pressuring:** number of iDLs pressuring the QB on the play
- **front_3:** if the number of DL on play (Players with hand on the ground) is less than or equal to 3
- **front_4:** if the number of DL on play is equal to 4
- **mixed_front:** if the number of DL on play is greater than 4 (small sample of plays)
- **shotgun:** dummy variable for shotgun formation (pass)
- **ScoreDiff:** Score differential before at the moment of the play
- **olb_pressuring:** number of OLBs pressuring the QB on the play

Run Defense Analysis: Evaluation Method

- **Expected Points Added (EPA):** A Measure of play efficiency. Difference between expected points (EP) at the beginning of the play and EP at the end of the play
- Since the defensive line is the first line of defense for run plays, we felt comfortable using Defensive EPA (**DEPA**)
- EPA facilitates normality assumption and is a good way to account for down/distance situations as opposed to raw Offensive Yardage

Run Defense Analysis: Evaluation Method cont.

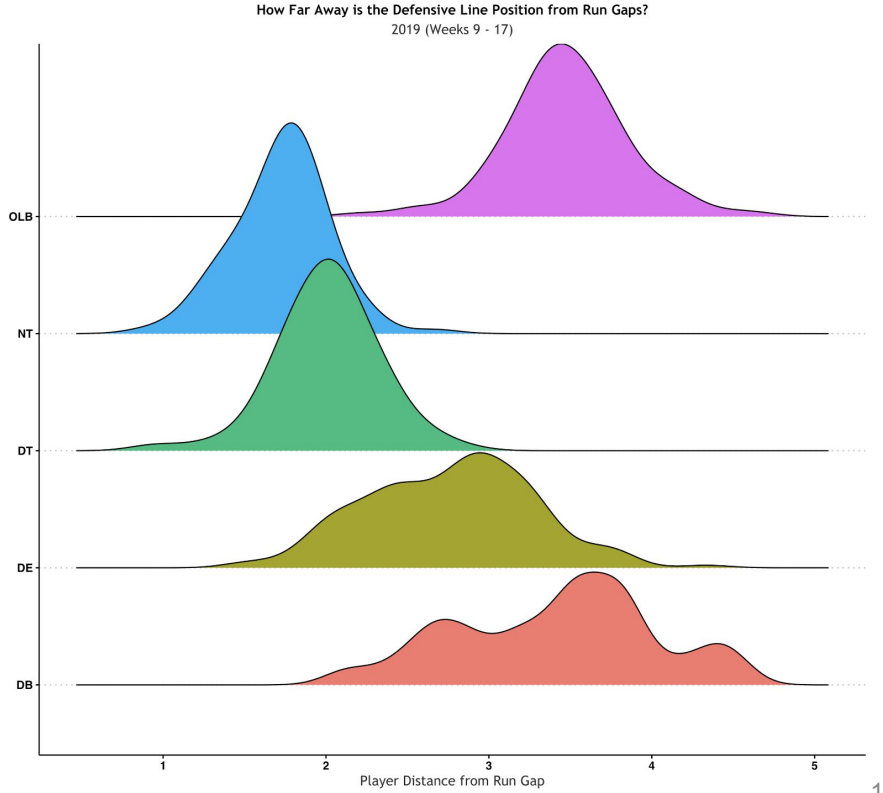
Following the principle from [Yurko, Ventura, Horowitz 2019], we will be finding the defensive individual points added (**DiPA**) for each player:

"We refer to an intercept estimating a player's average effect as their individual points/probability added (iPA), with points for modeling EPA and probability for modeling WPA. Similarly, an intercept estimating a team's average effect is their team points/probability added (tPA)" [Yurko, Ventura, Horowitz 2019]

Our goal will be to take DiPA a step further by only looking at plays in which the player had a chance to be involved, we will call it: **Credited Defensive Individual Points Added (cDiPA)**

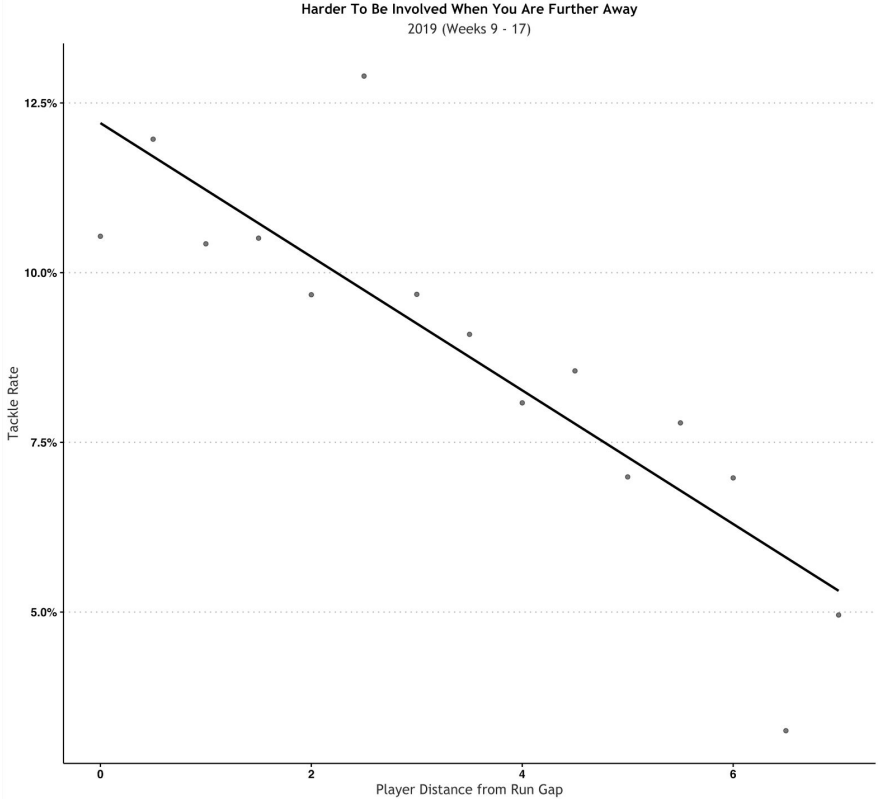
Run Defense Analysis: Evaluation Method cont.

- Defensive line players are at the mercy of Offensive Gap selection on Run Plays. (Especially when it comes to Edge Players)
- An OLB on the other side of the line, on a stretch play, will not be as involved as the DT or DE on the side of the Run Play.
- When a defender is run at, it is important that he does his job of plugging the run gap to the best of his ability.



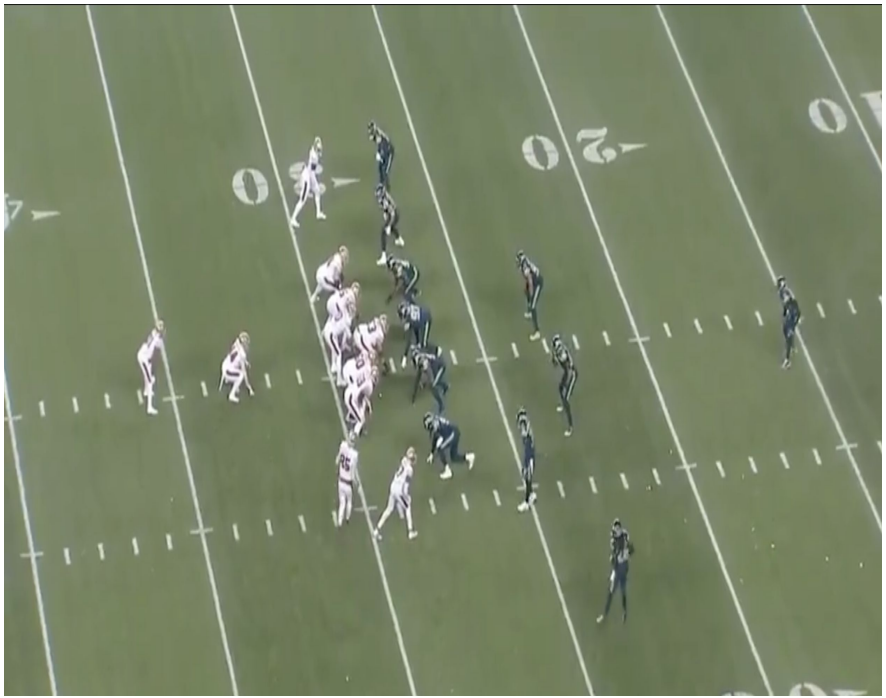
Run Defense Analysis: Evaluation Method cont.

- A Tackle is the most impactful EPA play a defensive lineman can make in run defense.
- On plays where tackles were not made by DL, opposing offenses gained .194 EPA/Run
- An assisted tackle from DL yielded -.203 EPA/Run, while a solo tackle was -.29 EPA/Run.
- Being further away from the run gap means that the player making a tackle on the play is much less likely.



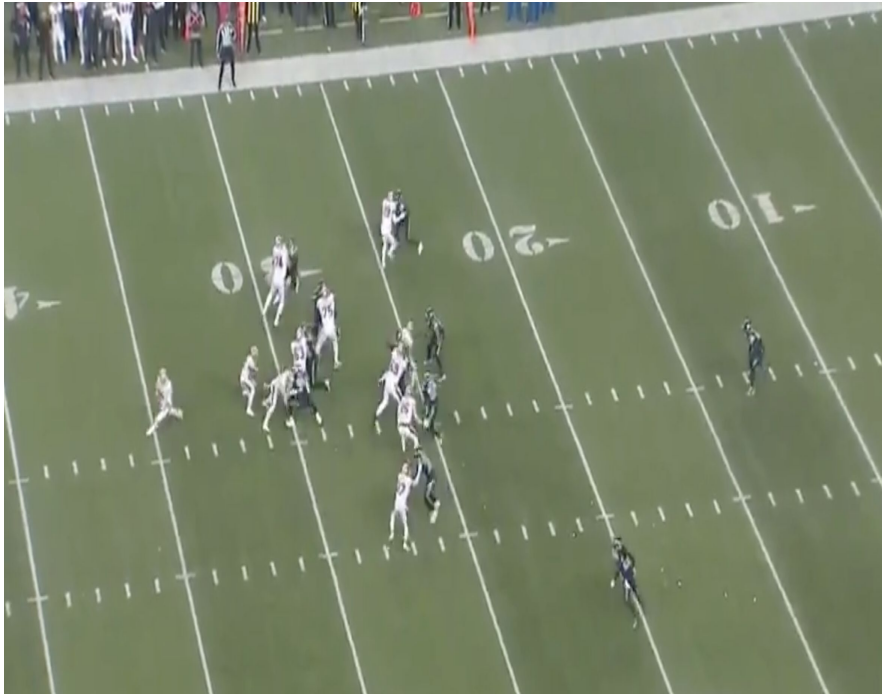
Run Defense Analysis: Example Play

- This Seahawks-49ers Run Play from week 17 (2019) is a good example of how our variables allow us to see more context in a play.
- In DataSet, Seahawks have a front_4 variable, with an OLB on the edge of the line.



Run Defense Analysis: Example Play

- Run is at the Left Off-Tackle B Gap here (run_num = 6), and two primary defenders get a RunAtDefender designation here (Poona Ford and Rasheem Green)
- Both Primary Defenders blow up the Offensive Lines blocks and force Raheem Mostert to hesitate.
- Poona Ford and Rasheem Green deserve credit for the impact they make on this play. They did their job extremely well



Run Defense Analysis: Example Play

- Ezekiel Ansah comes in from the left side on this play and makes an assisted tackle. If we were to only give credit to the tackling player on this play, we would completely miss the impact that Ford and Green make.
- **This is the idea behind run cDiPA**, to try and understand the impact of Players when they are in positions to be involved in the run play.

Mixed Effects Model - Run: Finding a player's intercept

Mixed effects model to find each player's DEPA intercept, which we are calling DiPA.

- Response variable: Resulting EPA on the play
- Fixed Effects: mean_dist + min_dist + min_dist_2 + distance_from_gap* + num_DT + num_NT + num_DE + num_OLB + Yardline_100 + ScoreDiff
- Random Effects: PlayerId:distance

**distance_from_gap was added to preserve a "continuous nature" to our distance from run gap metric. We want to control for the situation in more detail than just the "distance" label (which is a factor) interacting with player*

Mixed Effects Model - Run: Finding a player's intercept cont.

Here is where DiPA turns into cDiPA. We are trying to credit EPA only when the defender is close enough to impact the play.

- By making each player interact with distance, we are able to look at a each player's intercepts at each distance.
- We kept only each player's intercepts when they are close or at mid distance from designed run
- We grouped by player using their mean intercept (close and mid distance). The mean is each player's **cDiPA**

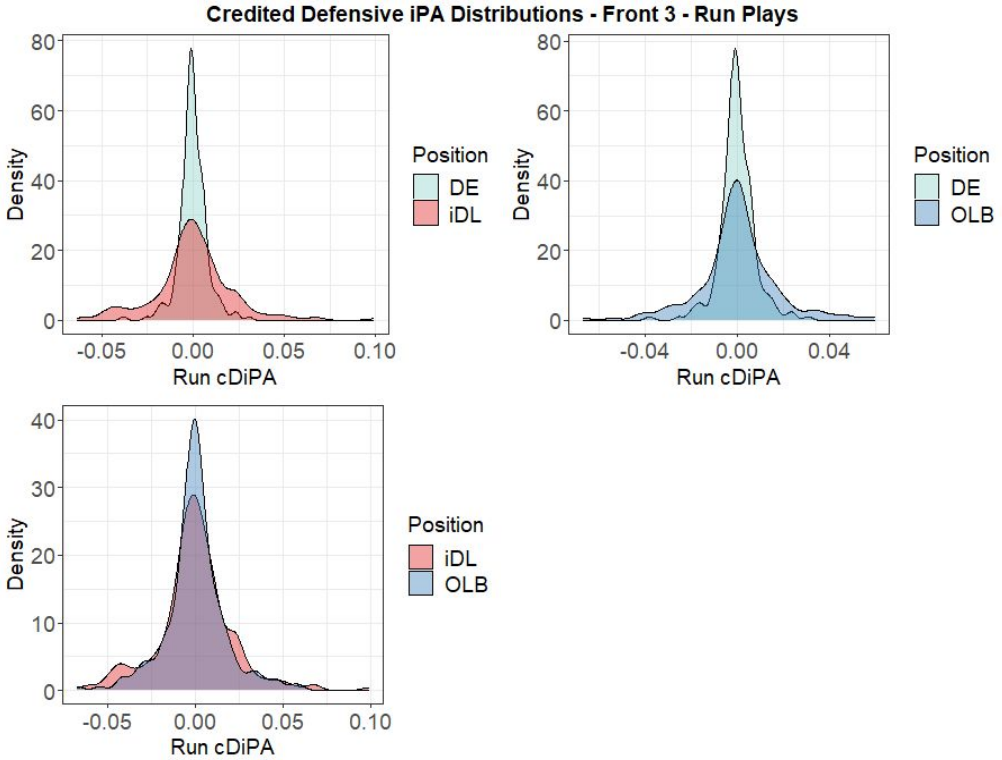
*We did subsamples by filtering effective or broad positions, depending on the analysis, and ran the model for each position**

Mixed Effects Model - Run: Results

In Front 3:

In run defenses, from high to low, the order of positional value is the following:

1. iDL (variance: 4.67e-04)
2. OLB (variance: 2.99e-04)
3. DE (variance: 6.03e-05)

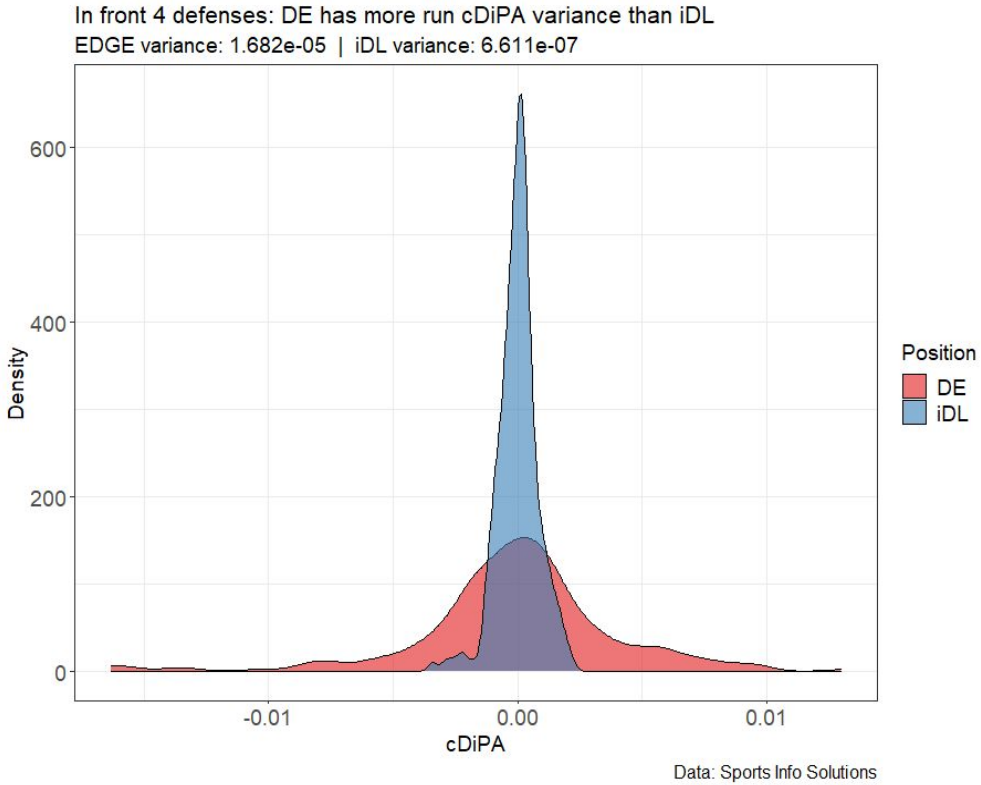


Data source: Sports Info Solutions

Mixed Effects Model - Run: Results cont.

In Front 4:

- There are some instances of LBs lined-up on the outside but, due the nature of the formation, we will only analyze DEs
- We also grouped NT and DT together as iDL.
- **Our model found that DE is significantly more ‘valuable’ than iDL in a front 4 run defense.**

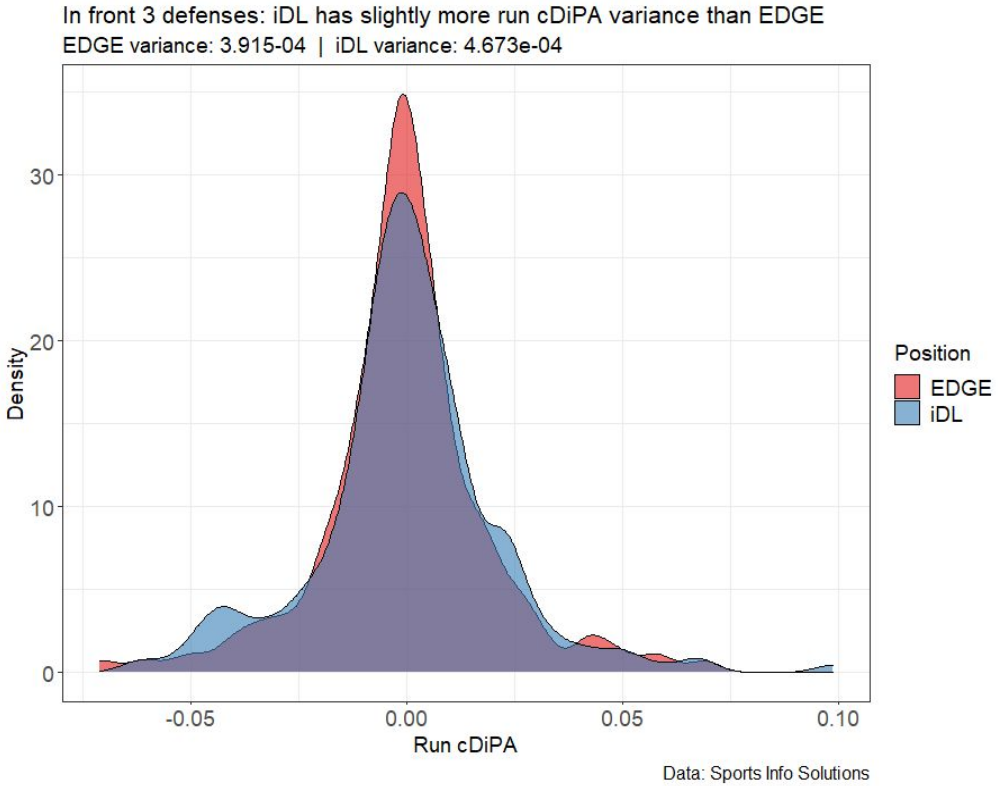


Mixed Effects Model - Run: Results cont.

In Front 3:

- In a front 3 run defense, when comparing our two broad positions (iDL vs EDGE), we find they have similar variance.
- However, **iDL Defenders still carry a bit more variance.**

1. iDL (variance: 4.673e-04)
2. EDGE (variance: 3.915e-04)



Run Defense Analysis: Interpretation

- **iDL defenders are the most valuable players in a front 3 defense** when **defending the run**, slightly over EDGE defenders (specifically OLBs)
- It makes sense that iDL in a front 3 would have much more importance than in a front 4, as they have twice the responsibility of a front-4 iDL.
- **DE is the most valuable position in a front 4 defense when defending the run**
- When defending the run, EDGE positions are valuable regardless of base defense (either 3-4 or 4-3).
- **Individual talent is considerably more impactful in a front 3 than a front 4** defense when defending the run. When comparing variances of both fronts, we can see that variances are larger in front 3 defenses

Run Defense Analysis: Limitations and Future Analysis

- No information on whether players were double-teamed, which could be seen as a ‘talent’, as some players are double-teamed at a higher rate than their peers. [Walder, 2019]
- While Penalties are left out of this DataSet, it would be interesting to see if any Defensive Players force Offensive Holding penalties at a higher rate than the rest of their position.
- We wanted to add Offensive Team as a random effect in our models. However,possibly due to sample size, it caused our Front 4 models to not work so we ended up dropping the variable to keep a fair comparison.
- This is a relatively small sample, having more than just these 8 weeks would allow us to properly assess the stability of this metric.
- Some teams may choose to be more reliant on their backside linebackers to close a gap as opposed to their defensive line. Having all LB data would possibly help in our assessment of team schemes.
- Tracking data would allow us to know post snap positioning of Defensive Line players, which could allow for improvements in assigning responsibilities.

Pass Defense Analysis : Evaluation Method

- Sacks are the most impactful play that a DL can have in the pass-game. [Hermsmeyer, 2020]
- Counting total sacks, as a volume stat, is considered a “noisy” metric since pressure-to-sack conversion rate does not carry from season to season. [Riske, 2020]
- In addition, Riske shows that “lucky” players (high pressure-to-sack conversion rate during a season) often overproduce “skilled” players (high pressure-rate during a season) in terms of cumulative EPA on plays where they sacked or pressured the QB

Pass Defense Analysis : Evaluation Method cont.

- Because of the previously mentioned reasons, we didn't feel comfortable using defensive EPA, sacks, or pressure-to-sack rate to measure individual talent
- Instead, we will focus on pressures, more specifically, **how much more likely a player is to pressure a QB compared to the average**
- We will try to find the increased probability that each player represents (player *i*), when the goal is to Pressure the QB, in form of **Log-Odds**
    - Controlling for certain parameters
    - Only when player *i* is rushing
    - Not predicting whether QB will be pressure during play,but whether player *i* will pressure the QB
- We call this: **iLog-Odds of Pressure**

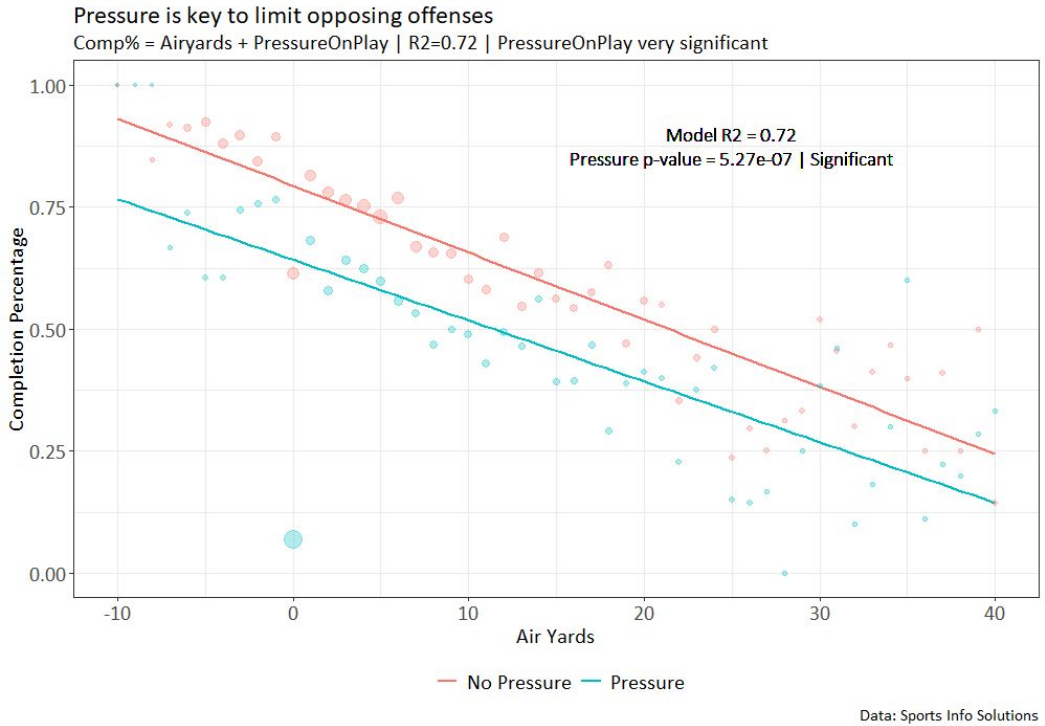
Pass Defense Analysis : Evaluation Method cont.

How impactful are QB pressures?

As our plot shows, QB pressures significantly reduces avg completion % regardless of Air Yards.

During weeks 7-19 of 2019 season:

- Avg EPA/Pass without pressure: 0.204
- Avg EPA/Pass with pressure: -0.40



Mixed Effects Logistic Regression - Pass: Finding a player's intercept

Mixed effects logistic model to find each player's Log-Odds of Pressure intercept, which we are calling **iLog-Odds of Pressure**.

- Response variable: Player *i* pressuring the QB during play *n*
- Fixed Effects: ToGo:Down + Yardline_100 + Down + ToGo + ScoreDiff +shotgun + blitz + (number of players from other positions pressuring)
- Random Effects: PlayerId:IsRushing

*We did subsamples by filtering effective or broad positions, depending on the analysis and ran the model for each position**

Mixed Effects Logistic Regression - Pass: Finding a player's intercept cont.

Just like we did with cDiPA, we are trying to give credit only when the player is involved. In this case, only when player *i* is rushing the passer.

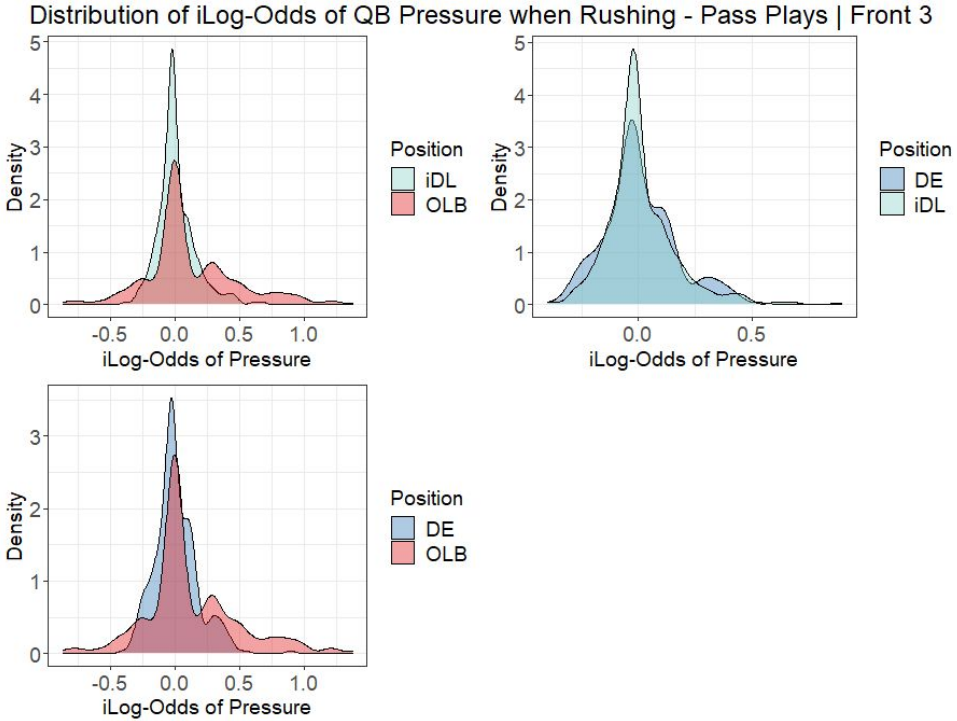
- By making each player interact with IsRushing variable, we are able to look at a each player's intercepts when rushing.
- We kept only each player's intercepts when they are rushing
- The remaining intercept is each player's **iLog-Odds of Pressure**

Mixed Effects Logistic Regression - Pass: Results

Front 3:

In Front 3 pass defenses, from high to low, the order of positional value is the following:

1. **OLB (variance: 0.130)**
2. **DE (variance: 0.028)**
3. **iDL (variance: 0.022)**



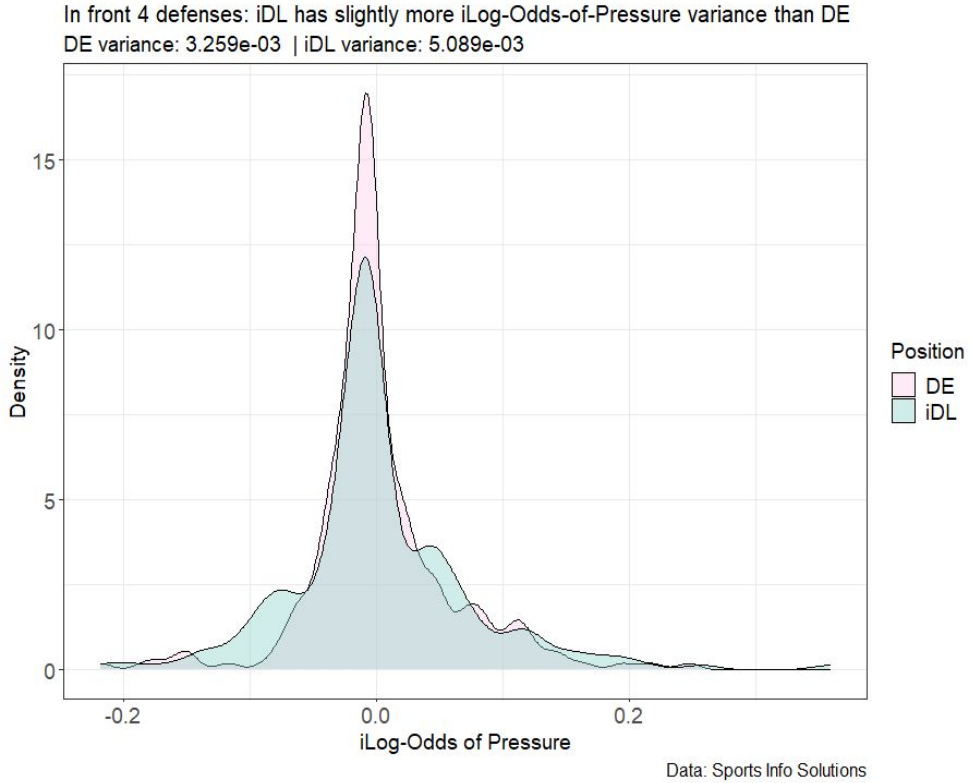
Mixed Effects Logistic Regression - Pass: Results cont.

Front 4:

We are analyzing broad positions as we did in run analysis.

iDL is slightly more valuable than DE in front 4 pass defenses

1. **iDL (variance: 5.089e-03)**
2. **DE (variance: 3.259e-03)**

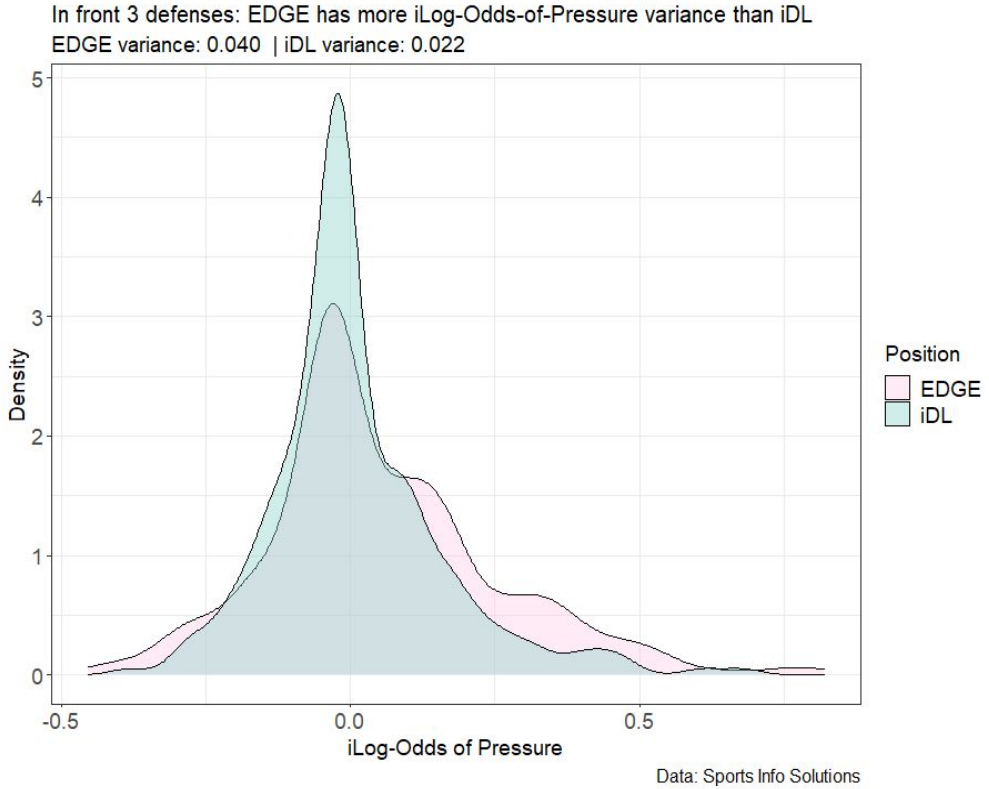


Mixed Effects Logistic Regression - Pass: Results cont.

Front 3:

When comparing broad positions, **EDGE Defenders are more valuable than iDL in a front 3 pass defense.**

1. **EDGE (variance: .040)**
2. **iDL (variance: .022)**



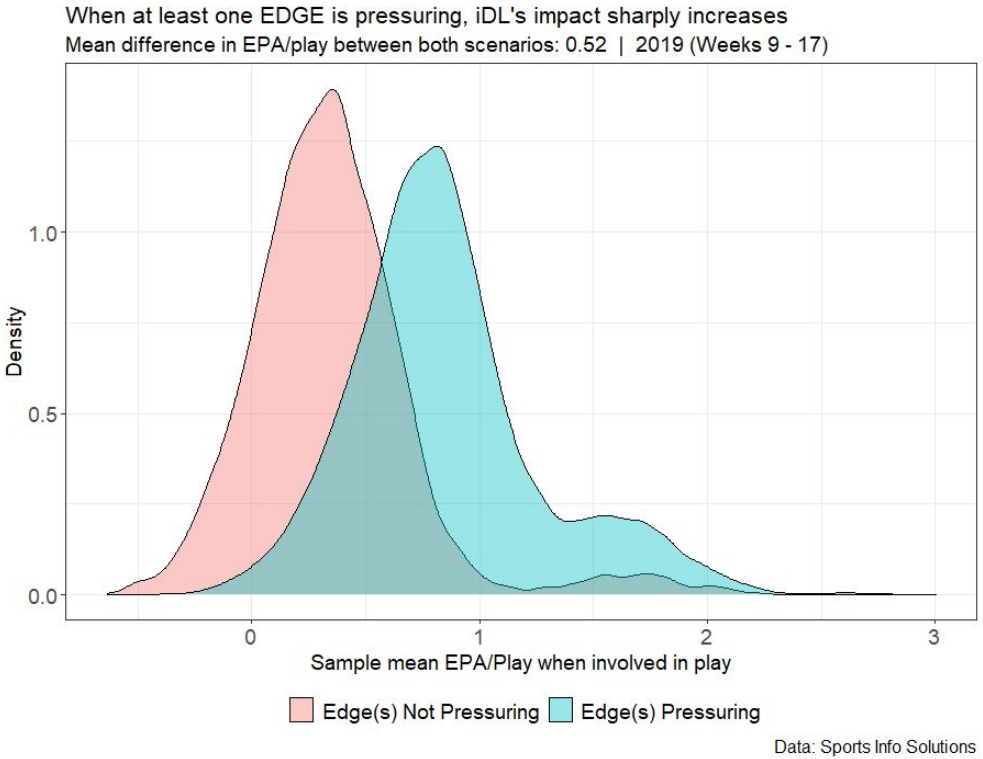
Pass Defense Analysis: who helps who?

- We found EDGE defenders are more valuable than iDLs, when defending the pass, in a front 3 defense
- Also, that iDL position is slightly more valuable than DE, when defending the pass, in a front 4 defense
- The model we used to estimate iDL variance took EDGE pressure into consideration
- The model we used to estimate EDGE variance did the same with iDL.
- Now we are interested in finding out which position helps the other the most
- To address this, we looked at:
    - Avg EPA for each player lined-up in position *a* when they sacked or pressured the QB during the play, and position *b* **was pressuring the QB during the play**
    - Same as previous but when position *b* **was not pressuring the QB during the play**
    - Then, we ran simulations and **compared the sample mean distributions of both scenarios, for both positions**

Pass Defense Analysis: who helps who? cont.

Generally, the average impact of iDL players sharply increases when there is one or more EDGE pressuring the QB during the play

The difference between the mean of these two distributions, in these simulations, was 0.52 (pressure - no pressure from other position)

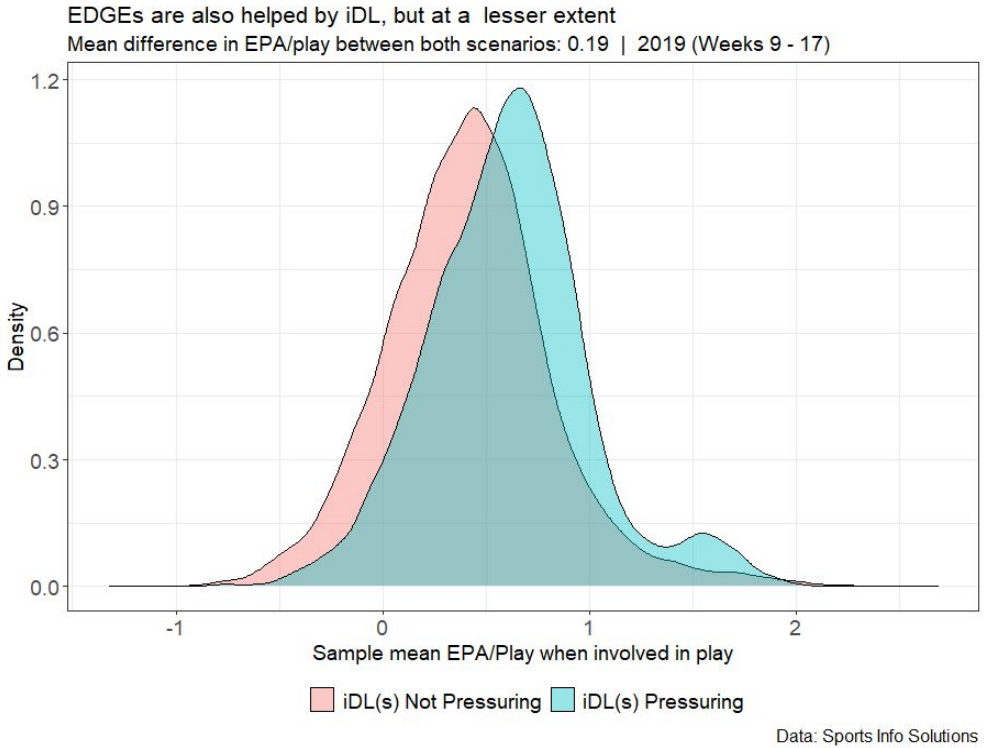


Pass Defense Analysis: who helps who? cont.

Generally, the average impact of EDGE players increase when there is one or more iDL pressuring the QB during the play

The difference between the mean of these two distributions, in these simulations, was 0.19 (pressure - no pressure from other position)

After looking at both results, we determined that EDGEs help iDLs at a greater extent



Pass Defense Analysis: Interpretation

- In a **front 3 pass defense**, all positions are relatively valuable (compared to a front 3 run defense), but **OLB is still most valuable, with DE as second.**
- In a **front 4 pass defense: iDL are more valuable than DE**; however, the difference is narrow, and when taking the “who helps who” analysis into consideration, we are inclined to believe there is an **argument for DE being more valuable**
- **Individual talent is considerably more impactful in a front 3 than a front 4** defense when defending the pass. When comparing variances of both fronts, we can see that variances are larger in front 3 defenses
- Distribution of talent in pass defense seems to be more equally distributed among DL positions compared to run defense

Pass Defense Analysis: Limitations and Future Analysis

- Knowing which players were first to pressure the Quarterback would allow us to have an additional metric to measure pass-rushing ‘talent’
- Knowing which players are being double teamed/chip blocked on Pass Plays would also help us adjust the expectation of that player, due to the harder job they have than other players
- This is a relatively small sample, having more than just these 8 weeks would allow us to properly assess the stability of iLog-Odds of Pressure
- Having multiple seasons could allow us to measure year-over-year consistency of iLog-Odds of Pressure
- We wanted to add Offensive Team as a random effect in our models, but due limited data, we didn’t feel comfortable in terms of the significance and stability of the variable. For example: Some teams had less games due bye-weeks. More data would make the use of this variable feasible. Same logic applies to a possible home/away variable

Final Answers and Conclusions: Question 1

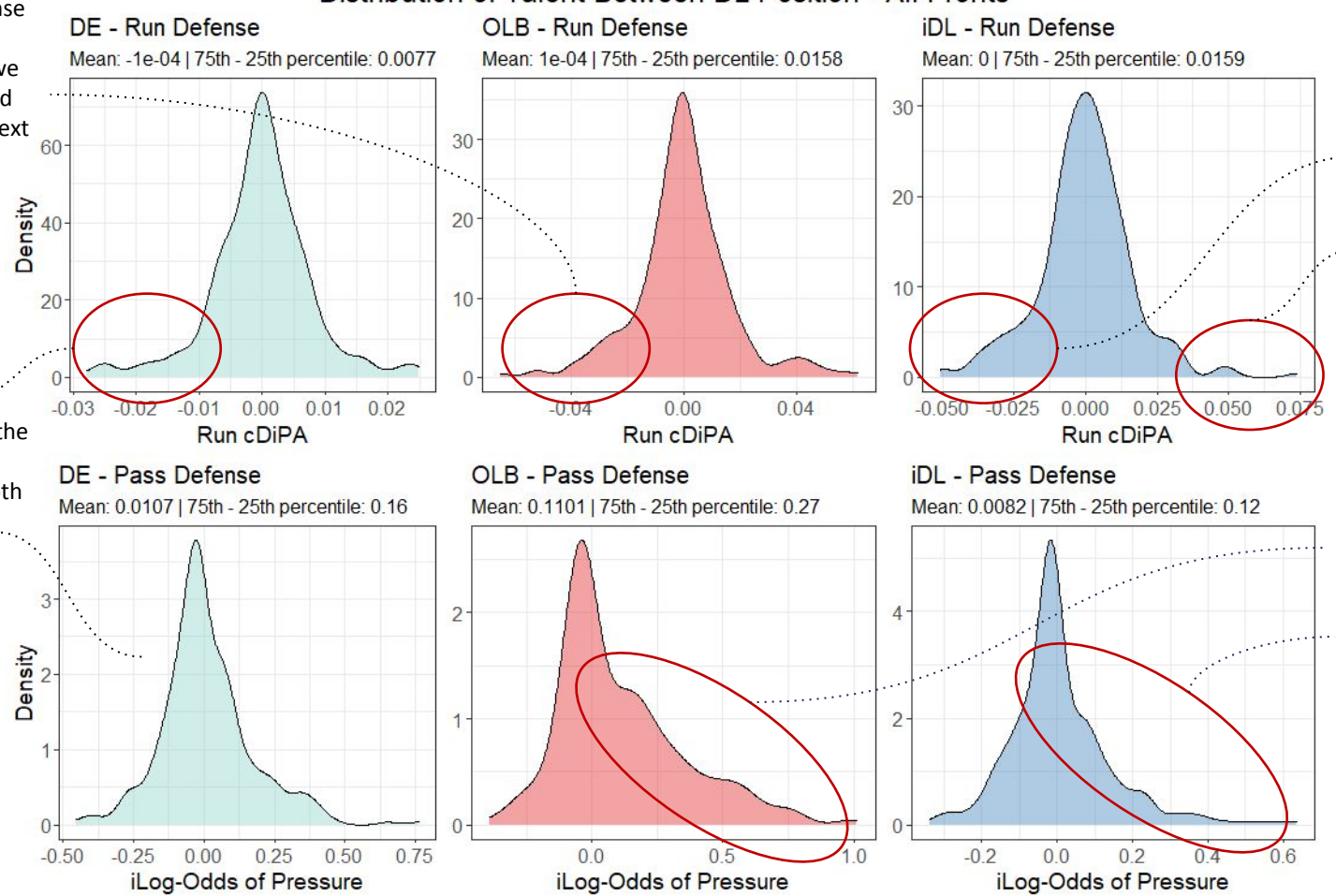
- EDGE defenders are generally the most valuable players in an NFL defensive line due their individual impact in both run and pass defense.
- The overall variance in individual impact (talent) for EDGE defenders is generally larger than iDLs, as we found in our run and pass defense analysis; therefore, the drop-off from a high-end EDGE defender to a low-end EDGE defender is much higher and more costly than a iDL.
- To reference our first plot (slide 6): in such example, EDGE defenders would be position “b” (more valuable), while iDLs would be position “a” (less valuable).
- The more specific answer for this question, in terms of defensive fronts and effective positions, will be addressed in answer for question 3.

Final Conclusions: Question 2

- First we will show plots showing the distribution of talent among DL positions, as we defined them
- On following slides, we will be providing our interpretation in applicable football scenarios

OLB in run defense is slightly bottom-heavy, we would say second in run defense next to iDL.

DE seems to be the most equally distributed in both run and pass defense



iDL in run defense seems to be much more bottom heavy, when compared to DE and OLB in run defense, by comparing their respective higher and lower tails

OLB in pass defense seems to be the most top-heavy, compared to DE and iDL by a considerable margin, differences between 75th and 25th percentiles suggest this as well

Data source: Sports Info Solutions

Final Conclusions: Question 2 cont.

- In more recent times, EDGE rushers are being valued at their ability to rush a Quarterback and not necessarily their role in the run game (The 49ers,Bears,Packers,Cowboys and Kansas City all invested significant capital into EDGE rushers recently). We can find a good example of this when we look at the distributions in the previous slide. For specific positions, OLB variance is more normally distributed against the run, while it is much more top heavy defending the pass. The drop off from a top OLB against the pass is much much steeper.
- When we look at DE's we can see more versatility when it comes to both defending the run vs defending the pass. DE's usually line up more inside than OLB and will be more involved in running plays, therefore they do need to have talent against stopping the run. However they have the lowest variance of all positions against the run. There is a jump in variance when defending against the pass for DE's, showing that there is still value to be gained from a top end DE. When we group these two into our Broad EDGE rusher designation, we can understand that EDGE players have the most variance when rushing the passer.

Final Conclusions: Question 2 cont.

- For iDL, we can see in the previous slide that the 75th-25th percentile for iDL vs pass is lower than both DE's and OLB's, while being the highest in the Run Game. Similar to the OLB example before, the variance between a good iDL vs the run is much steeper than against the pass. This is especially true in a front 3, where you will see more 0 techniques than in a front 4. In slides 24 and 25, we can see the importance of having run stopping iDL in a front 3, with iDL having a higher variance than EDGE defenders in these front.
- In a front 4, we will see more potential for a primary 1-technique who will defend against the run, with more opportunity for 3 technique DT's who are talented against the pass (Aaron Donald, Chris Jones). We can see this evidence in slides 34 and 35, with iDL having a slightly higher variance than EDGE rushers in a front 4 when it comes to passing defense. Overall, an iDL's importance to a team will come more in the form of defending the run.

Final Conclusions: Question 3

Front 3 DL:

- **OLB is the most valuable position when playing a base 3 DL front**, due their much greater impact in pass defense. OLB was less ‘valuable’ than iDL in run defense by only a narrow margin.
- iDLs are more valuable when playing in a front 3 compared to a front 4 defense, against the run. We could argue they are more valuable than DEs in front 3 defenses.

Front 4 DL:

- In front 4 defenses, there are instances of more than 4 players having their hand in the ground and rushing the passer. These situations are “special fronts”, not considered a “base” type of defense. Therefore, we decided to exclude them from our front 4 analysis, unlike we did for front 3 defenses
- Our advice, in terms of roster construction, would be: **the most valuable position in a front 4 is a versatile DE that can line-up in different EDGE spots**, both when defending the pass and the run.
- We found iDL to be much more valuable when defending the pass in front 4 compared to defending the run in a Front 4. As touched on in our previous slide, front 4 iDL will have more 3-tech pass rush specialists than a front 3.
- However, DE are more consistent in terms of their impact, regardless of situation, in a base front 4 defense

Works Cited

1. Yurko, R., Ventura, S., & Horowitz, M. (2019). nflWAR: a reproducible method for offensive player evaluation in football, *Journal of Quantitative Analysis in Sports*, *15*(3), 163-183. doi: https://doi.org/10.1515/jqas-2018-0010
2. Hermsmeyer, J. (2020) Exactly How Much Does A Great Pass Rush Hurt An Offense? https://fivethirtyeight.com/features/exactly-how-much-does-a-great-pass-rush-hurt-an-offense/
3. Riske, T. (2020) PFF Data Study: Debunking the myth of the "sack artist" https://www.pff.com/news/nfl-pff-data-study-sack-artist-pass-rushers
4. Walder, S. SethWalder. (2019, Dec 19).Double team rate as an edge rusher (x) by pass rush win rate as an edge rusher (y) https://twitter.com/SethWalder/status/1205222343120957449?ref_src=twsrc%5Etfw%7Ctwcamp%5Etweetembed%7Ctwterm%5E1205222343120957449%7Ctwgr%5E&ref_url=https%3A%2F%2Ftheramswire.usatoday.com%2F2019%2F12%2F13%2Fnfl-rams-aaron-donald-pass-rush-win-rate%2F

Thank you

Thanks to the SIS team for preparing this competition and supporting a great cause.

- Sam and Adrian

Feel free to reach out to either:

- **Sam Struthers**; strut101@mail.chapman.edu; (760)238-8774; https://www.linkedin.com/in/sam-struthers-a0003b118/
- **Adrian Cadena**; adrian.cadena@utdallas.edu; (956) 331-3726; https://www.linkedin.com/in/adriancadenam/